TVA

Tennessee Valley Authority, 1101 Market Street, Chattanooga, Tennessee 37402-2801

February 18, 2000

Mr. William Grimley
Emissions Measurement Center
United States Environmental
Protection Agency
Interstate 40 and Page Road
4930 Old Page Road
Room Number E-108
Durham, North Carolina 27709

Dear Mr. Grimley:

TENNESSEE VALLEY AUTHORITY (TVA) - SUBMITTAL OF MERCURY STACK SPECIATION TEST REPORTS FOR SHAWNEE AND WIDOWS CREEK FOSSIL PLANTS

Enclosed are three copies of the mercury speciation test reports for TVA's Shawnee (SHF) and Widows Creek (WCF) Fossil Plants. This information is being submitted as required by Part III of the U.S. Environmental Protection Agency (EPA) Mercury Information Collection Request (ICR), approved on November 13, 1998 by the Office of Management and Budget. The testing was conducted at SHF Unit 3 on October 27, 28, and 29 and at WCF Unit 6 on October 19, 20, and 21, 1999.

Part III of the ICR requires submittal of this information within 90 days after completion of the testing. TVA notified EPA in a letter dated January 7, 2000 that submittal would be delayed until February 18, 2000 due to the time required for the contractor who performed the testing to develop the test reports.

METCO ENVIRONMENTAL
P.O. Box 598
Addison, TX 75001
(972) 931-7127

SOURCE EMISSIONS SURVEY
OF
TENNESSEE VALLEY AUTHORITY
SHAWNEE FOSSIL PLANT
UNIT NUMBER 3 BAGHOUSE INLET DUCTS
AND OUTLET DUCT
WEST PADUCAH, KENTUCKY
FOR
ELECTRIC POWER RESEARCH INSTITUTE

OCTOBER 1999

FILE NUMBER 99-95SHW3

TABLE OF CONTENTS

Figures

Tables

1 INTRODUCTION

1.1 Summary of Test Program

The report summarizes the mercury speciation characterization study conducted at the Tennessee Valley Authority (TVA), Shawnee Fossil Plant (SHF), located in McCracken County, 7900 Metropolis Lake Road, West Paducah, Kentucky. The purpose of the study was to meet the requirements of Part III of the U.S. Environmental Protection Agency (EPA) Mercury Information Collection Request (ICR) approved on November 13, 1998 by the Office of Management and Budget. The Mercury ICR was issued by the EPA under authority of section 114 of the Clean Air Act (42 U.S.C. 7414).

As provided in Part III of the ICR, affected units were grouped into categories based on the type of emission control equipment installed and type of coal burned. TVA's SHF was randomly selected from one of EPA's categories for this testing. The testing was performed by METCO Environmental, Dallas Texas for the Electric Power Research Institute (EPRI), and TVA, on October 27, 28, and 29, 1999. The testing was conducted at SHF Unit Number 3 and consisted of simultaneous measurements of speciated mercury concentrations at the Baghouse A Inlet and Outlet Ducts. In addition, concurrent flow rate measurements at the Baghouse B Inlet and Outlet Ducts were performed and coal sampling was done to determine the mercury, chlorine, sulfur, ash and Btu content.

The sampling followed the procedures set forth in the Code of Federal Regulations, Title 40, Chapter I, Part 60, Appendix A, Methods 1, 2, 3B, 4, 5, 17, and 19; in the "Standard Test Method for Elemental, Oxidized, Particle-bound, and Total Mercury in Flue Gas Generated from Coal-Fired Stationary Sources (Ontario Hydro Method), Revised July 7, 1999; and ASTM Methods D2234, D6414-99, D2361-95, D-0516, D-3174, and D-3286.

1.2 Key personnel

The Table 1-1 summarizes key test personnel and affiliation.

Mr. Bill Hefley of METCO Environmental was the onsite project manager. Mr. Steve Bornsen, Mr. Shane Lee, Mr. Mike Bass, Mr. Jason Conway, Mr. Scott Hart, and Mr. Jason Brown of METCO Environmental performed the testing.

Mr. John Myers of the Tennessee Valley Authority acted as the utility representative. Mr. Bill Oberg of the Tennessee Valley Authority performed process monitoring and sampling.

Mr. Bill Clark of the Kentucky Department of Environmental Protection, Paducah, Kentucky, and Mr. Gerald H. Slucher of the Kentucky Department of Environmental Protection, Frankfort, Kentucky, observed the testing.

Mr. Paul Chu was the Electric Power Research Institute project manager.

Table 1-1 Test Program Organization

Organization	Individual	Responsibility	Phone Number
Project Team			
METCO	Bill Hefley	Project Manager	(972) 931-7127
Utility			
TVA	John Myers	Utility Representative	(423) 751-8855
TVA	Bill Oberg	Process Monitoring & Sampling	(423) 751-2766
QA/QC			
EPRI	Paul Chu	Project Manager	(650) 855-2812

2 SOURCE AND SAMPLING LOCATION DESCRIPTIONS

2.1 Process Description

SHF Unit Number 3 is a Babcock and Wilcox Company steam generator which began operating in 1953. SHF Unit Number 3 was retrofitted with Low NOx burners in April 1998. The steam generator is a dry bottom, wall-fired boiler with a nameplate generating capacity of 175 megawatts and a maximum heat input capacity of 1,691 MM Btu/hr.

Coal for Unit Number 3 is fed from the coal bunker (1 bunker per unit, 4 hoppers per bunker) to the coal scales (4 per unit), then into the pulverizers (4 per unit) before being pneumatically discharged to the boilers. Four burners per pulverizer were provided in the front wall of the furnace. Each burner is provided with an air register, throat cone, throat tile and holder, impeller and hub, a door for observation and lighting, oil atomizer, sprayer plates, and oil connection, and connections for coal pipers.

Bottom ash is sluiced to the ash pond along with dust from the coal scale dust collectors and pyrites from the pulverizers. Fly ash is collected and pneumatically transported to the fly ash transfer silo. Flue gases from Unit Number 3 discharges through Stack Number 1. A Process Flow Diagram is provided as Figure 2-1.

2.2 Control Equipment Description

Flue gases from Unit Number 3 are pulled through mechanical collectors (cyclones) and bagfilters (1 per unit) by induced draft fans. The air pollution control equipment is a Buell/Envirotech Model No. 10-324-12 consisting of 10 compartments with 324 bags per compartment. Unit Number 3 baghouse was designed for 585,000 acfm at 325 °F with an efficiency of 99.33%.

2.3 Flue Gas and Process Sampling Locations

2.3.1 Inlet Sampling Location

The sampling location on the Unit Number 3 Baghouse A Inlet Duct is 40 feet 8 inches above the ground. The sampling locations are located 30 feet 8 inches (3.81 equivalent duct diameters) downstream from a constriction in the duct and 22 feet 8 inches (2.82 equivalent duct diameters) upstream from a bend in the duct. This location did meet the requirements of EPA Method 1. A diagram of the inlet sampling locations is provided in Figures 2-2 and 2-3.

The sampling location on the Unit Number 3 Baghouse B Inlet Duct is 40 feet 8 inches above the ground. The sampling locations are located 30 feet 8 inches (3.81 equivalent duct diameters) downstream from a constriction in the duct and 22 feet 8 inches (2.82 equivalent duct diameters) upstream from a bend in the duct. This location did meet the requirements of EPA Method 1. A diagram of the inlet sampling locations is provided in Figures 2-2 and 2-3.

2.3.2 Outlet Sampling Location

The sampling location on the Unit Number 3 Baghouse Outlet Duct is 35 feet 8 inches above the ground. The sampling ports are located in a transition area of the duct. This location did not meet the requirements of Method 1, and was found to have cyclonic flow. The sampling was performed from the ports with an average angle of cyclonic flow less than 20 degrees. A diagram of the outlet sampling locations is provided in Figures 2-4 and 2-5.

2.3.3 Coal Sampling Location

The coal sampling locations are located at the coal scales immediately downstream of the coal bunkers. A diagram of the coal sampling locations is provided in Figure 2-6.

Figure 2-1
Process Flow Diagram

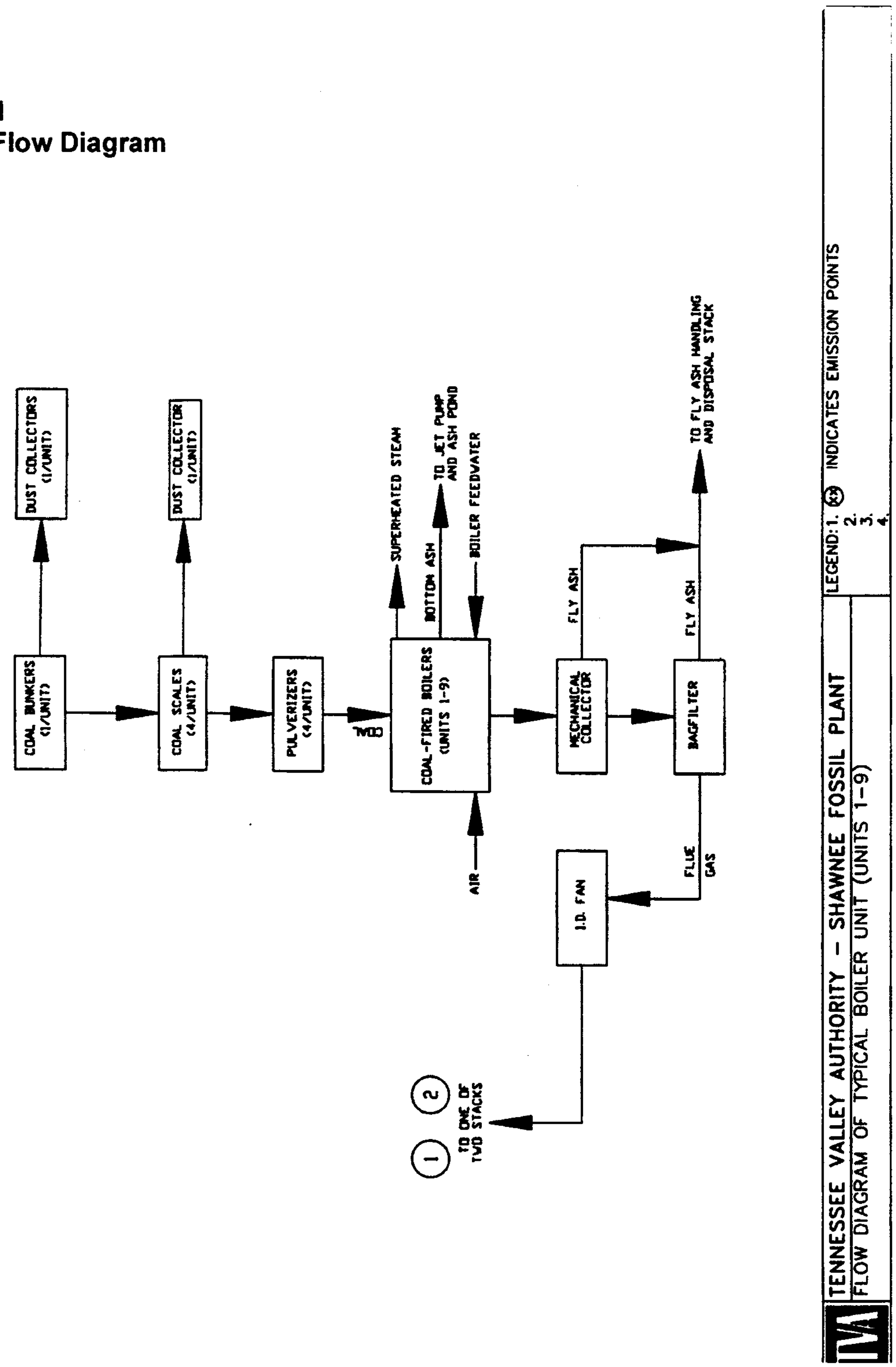


Figure 2-2
Description of sampling locations at Shawnee Unit Number 3 Baghouse A & B Inlet Ducts

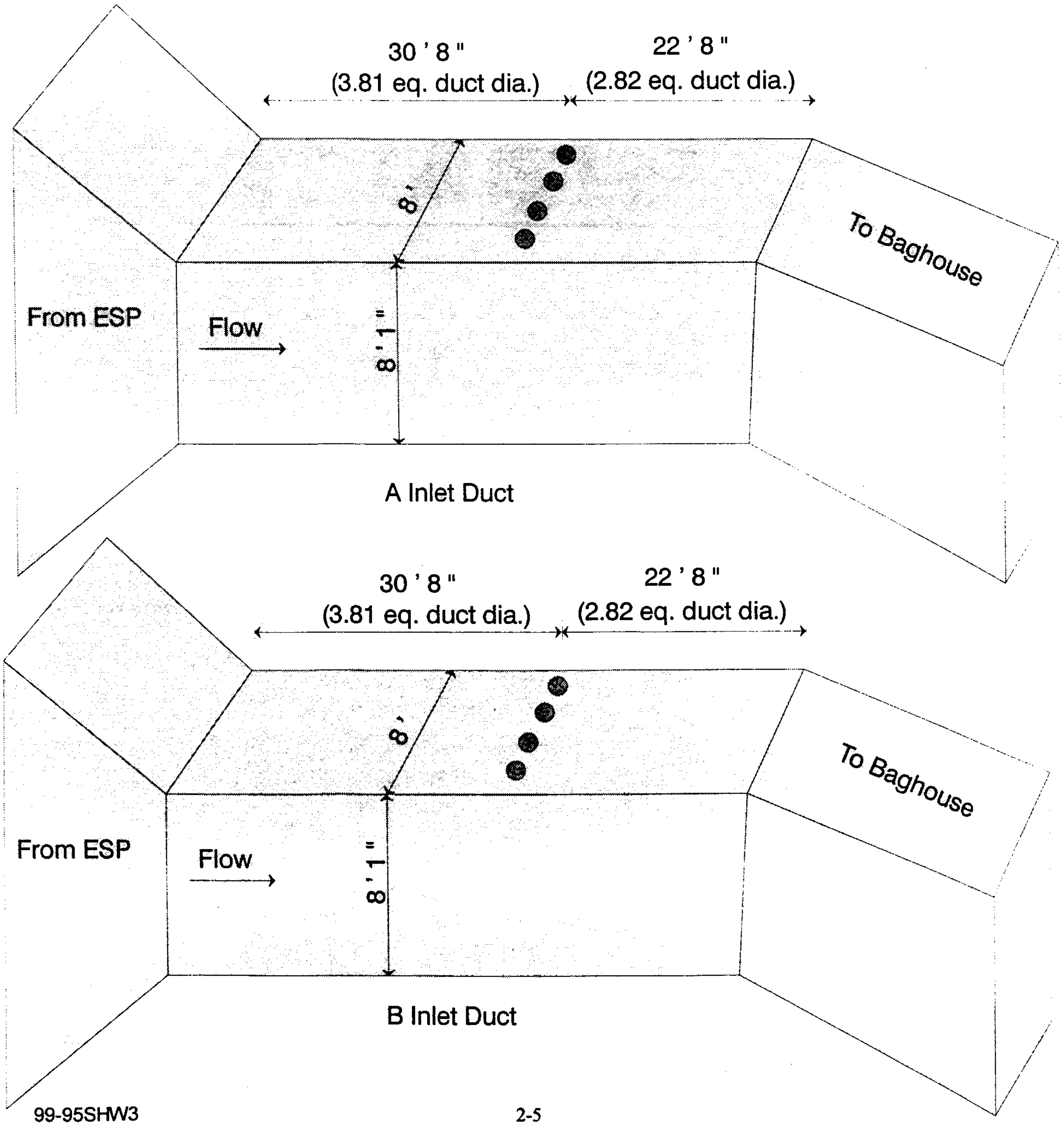


Figure 2-3
Description of sampling points at Shawnee Unit Number 3 Baghouse A & B Inlet Ducts

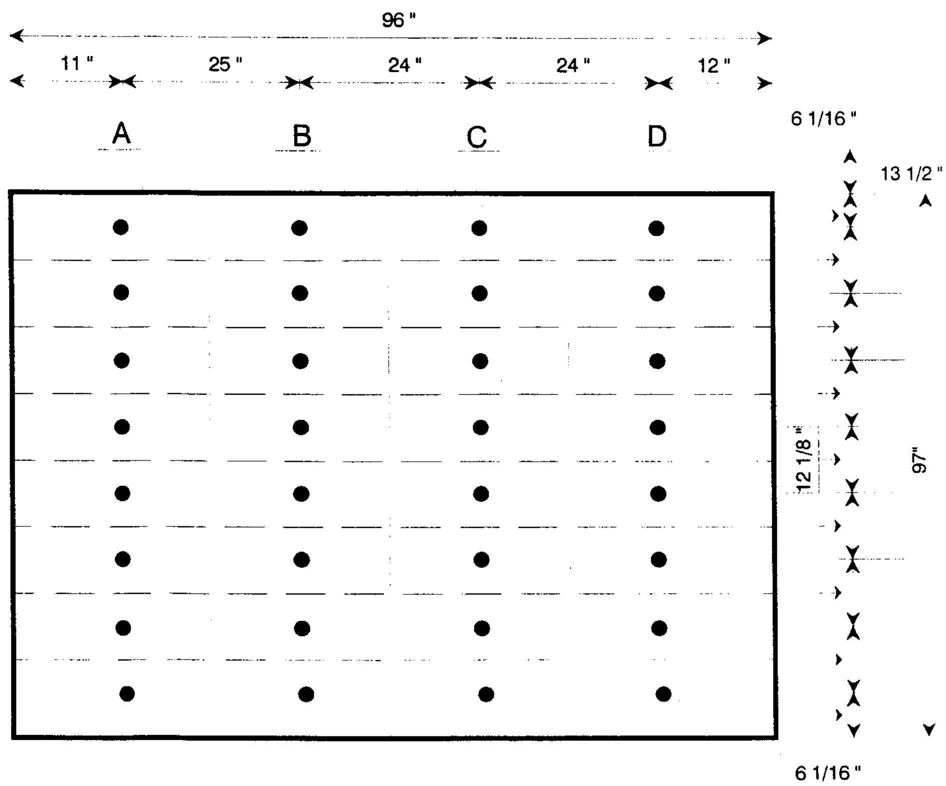


Figure 2-4
Description of sampling locations at Shawnee Unit Number 3 Baghouse Outlet Duct

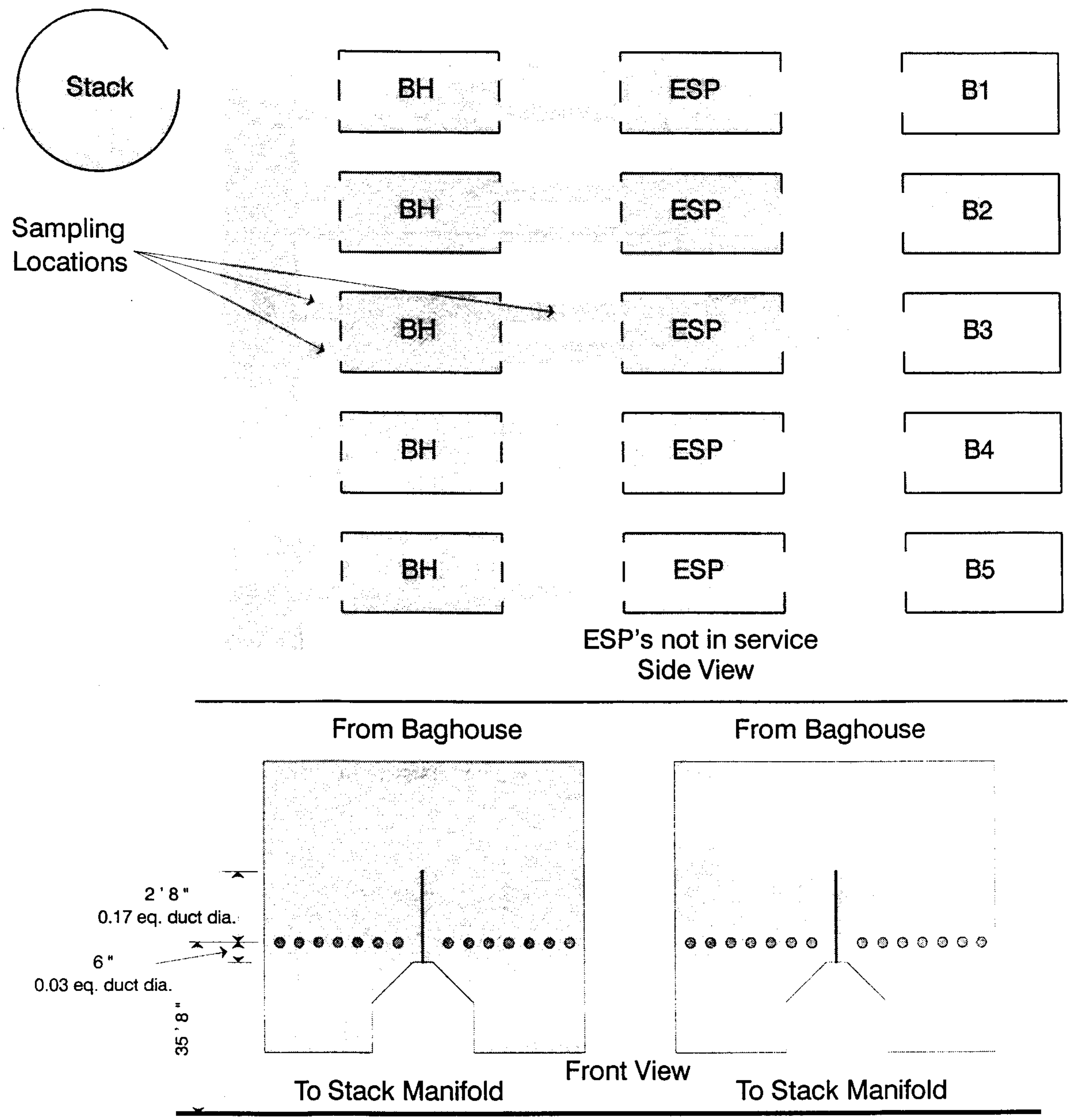


Figure 2-5
Description of sampling points at Shawnee Unit Number 3 Baghouse Outlet Duct

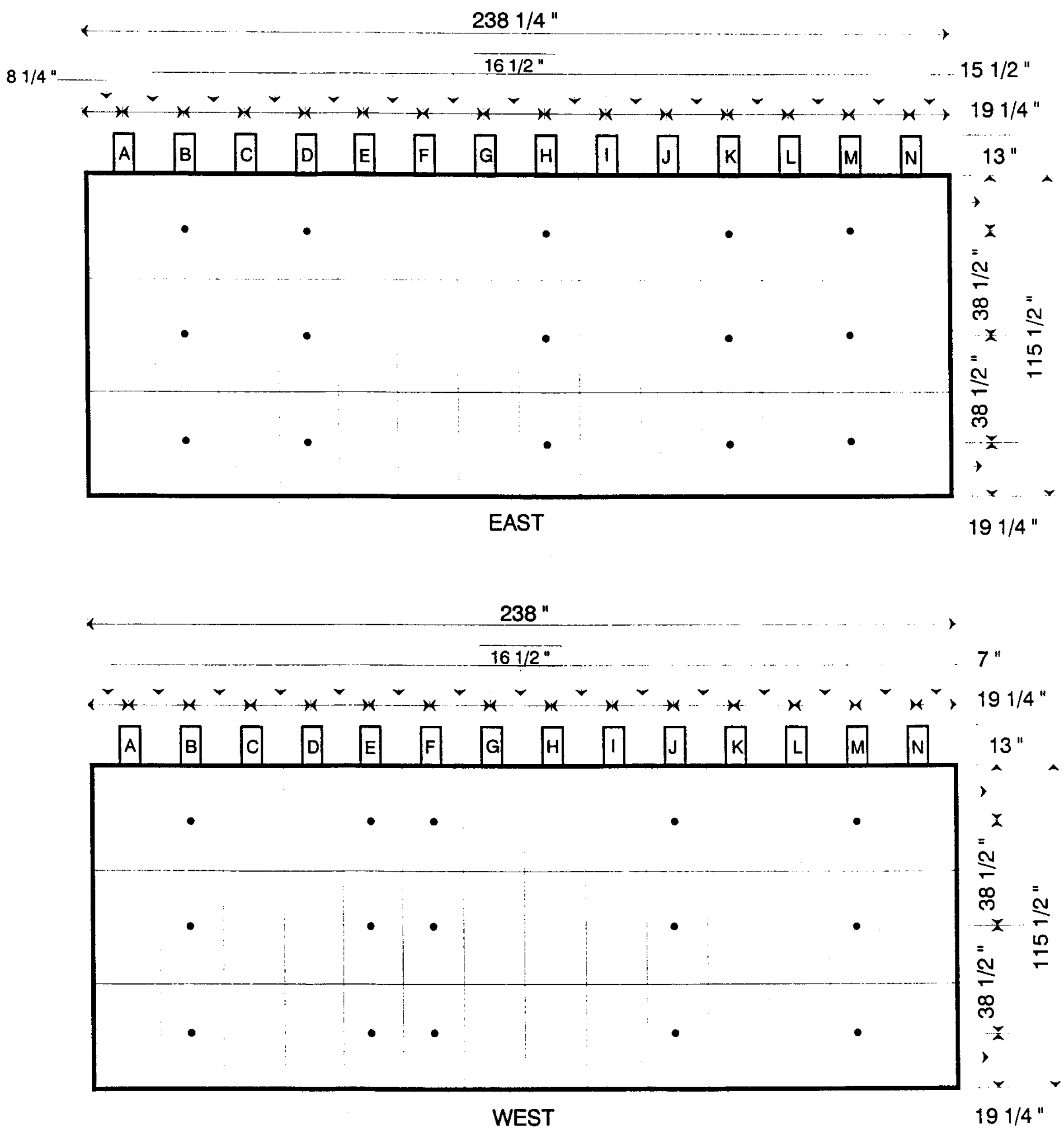
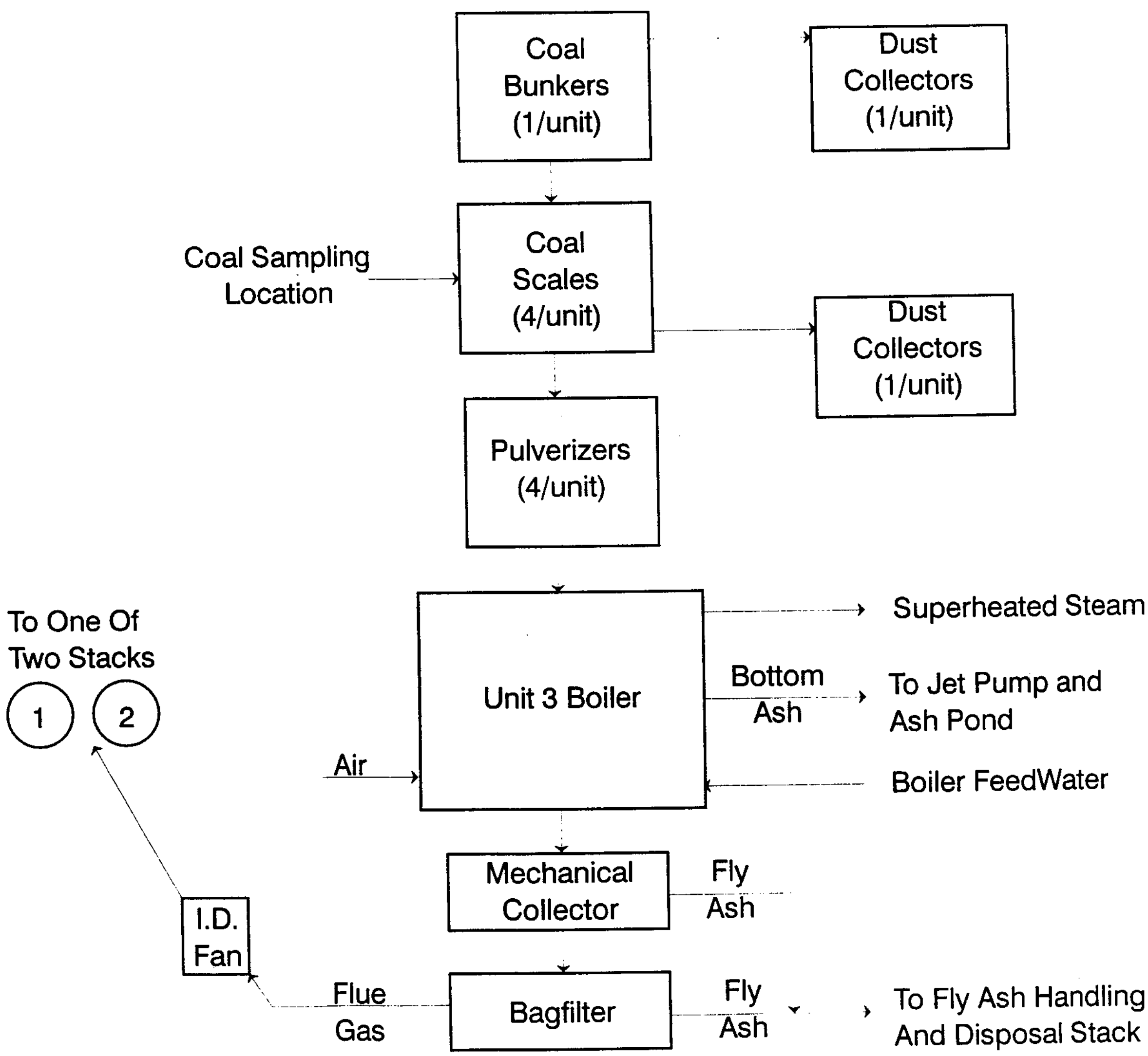


Figure 2-6
Description of coal sampling locations at Shawnee Unit Number 3



3 SUMMARY AND DISCUSSION OF RESULTS

3.1 Objectives and Test Matrix

3.1.1 Objective

The objective of the tests was to collect the information and measurements required by the EPA Mercury ICR. Specific objectives listed in order of priority are:

1. Quantify speciated mercury concentrations at the SHF Unit Number 3 Baghouse A Inlet Duct.
2. Quantify speciated mercury concentrations in the flue gas at the SHF Unit Number 3 Baghouse Outlet Duct.
3. Quantify fuel mercury, chlorine, sulfur, ash, and Btu content of coal burned simultaneously during the inlet and outlet tests.
4. Provide the above information for use in developing boiler, fuel, and specific control device mercury emission factors.

3.1.2 Test Matrix

The test matrix is presented in Table 3-1. The table includes a list of test methods to be used. In addition to speciated mercury, the flue gas measurements include moisture, flue gas flow rates, carbon dioxide, and oxygen.

Table 3-1
Test Matrix for Mercury ICR Tests at Shawnee Unit Number 3

Sampling Location	No. of Runs	Species Measured	Sampling Method	Sample Run Time	Analytical Method	Analytical Laboratory
Outlet	3	Speciated Hg	Ontario Hydro	150 min	Ontario Hydro	TestAmerica
Outlet	3	Moisture	EPA 4	Concurrent	Gravimetric	METCO
Outlet	3	Flue Gas Flow	EPA 1 & 2	Concurrent	Pitot Traverse	METCO
Outlet	3	O_2 & CO_2	EPA 3B	Concurrent	Orsat	METCO
Inlet A	3	Speciated Hg	Ontario Hydro	144 min	Ontario Hydro	TestAmerica
Inlet A	3	Moisture	EPA 4	Concurrent	Gravimetric	METCO
Inlet A	3	Flue Gas Flow	EPA 1 & 2	Concurrent	Pitot Traverse	METCO
Inlet A	3	O_2 & CO_2	EPA 3B	Concurrent	Orsat	METCO
Inlet B	3	Moisture	EPA 4	30 min	Gravimetric	METCO
Inlet B	3	Flue Gas Flow	EPA 1 & 2	Concurrent	Pitot Traverse	METCO
Inlet B	3	O_2 & CO_2	EPA 3B	Concurrent	Orsat	METCO
Coal Scales	3	Hg, Cl, Sulfur, Ash, and Btu/lb in coal	ASTM D2234	1 grab sample every 30-minutes per scale per run	ASTM D6414-99 (Hg), ASTM D2361-95 (Cl), ASTM D-0516 (S), ASTM D-3174 (Ash), and ASTM D-3286 (Btu/lb)	TestAmerica and Philip Services

3.2 Field Test Changes and Problems

Due to the uniformity and magnitude of the flow at the outlet sampling location, a 3 x 10 test matrix was used. A 6 x 4 test matrix was used at the inlet sampling location to provide more concurrent sampling. The outlet duct was found to have cyclonic flow. The sampling was performed from the ports with an average angle of cyclonic flow less than 20 degrees.

3.3 Handling of Non-Detects

This section addresses how data will be handled in cases where no mercury is detected in an analytical fraction. It should be noted that the analytical method specified in the Ontario Hydro Method has a very low detection limit, which is expected to be well below flue gas levels for most cases if the laboratory uses normal care and state of the art analytical equipment. However, there may be cases where certain fractions of a test do not show detectable mercury levels. This section addresses how non-detects will be handled in calculating and reporting mercury levels.

3.3.1 A single analytical fraction representing a subset of a mercury species is not detected.

When more than one sample component is analyzed to determine a mercury species (such as analyzing the probe rinse and filter catch separately to determine total particulate mercury) and one fraction is not detected, it will be counted as zero. Total mercury for that species will be the sum of the detected values of the remaining fraction(s). For example, if the probe rinse had ND < 0.05 μg and the filter had 1.5 μg, total particulate mercury would be reported as 1.5 micrograms.

3.3.2 All fractions representing a mercury species are not detected.
If all fractions used to determine a mercury species are not detected, the total mercury for that species will be reported as not detected, at the sum of the detection limits of the individual species.

For example, if the probe rinse were not detected at 0.003 µg and the filter catch were not detected at 0.004 µg, the reported particulate mercury would be reported as ND <0.007 µg. This is expected to represent a small fraction (<1%) of the total mercury, even under worse case scenario of 1 µg/Nm^3.

3.3.3 No mercury is detected for a species on all three test runs.
When all three test runs show no detectable levels of mercury for a mercury species, that mercury species will be reported as not detected at less than the highest detection limit. For example, if three results for elemental mercury are ND < 0.10, ND <0.13, and ND < 0.10, the results would be reported as ND < 0.13 (the highest of the three detection levels).

In calculating total mercury, a value of zero will be used for that species. For example, if particulate mercury were ND < 0.11 µg, oxidized mercury were 2.0 µg, and elemental mercury were 3.0 µg, total mercury would be reported as 5.0 µg.

In calculating the percentage of mercury in the other two species, a value of zero will be used. For the example listed in the preceding paragraph, the results would be reported as 0% particulate mercury, 40% oxidized mercury, and 60% elemental mercury.

3.3.4 Mercury is detected on one or two of three runs.

If mercury is detected on one or two of three runs, average mercury will be calculated as the average of the detected value(s) and half of the detection limits for the non-detect(s).

Example 1: The results for three runs are 0.20, 0.20, and ND < 0.10. The reported value would be calculated as the average of 0.20, 0.20, and 0.05, which is 0.15 µg.
Example 2: The results for three runs are 0.14, ND < 0.1, and ND < 0.1. The average of 0.14, 0.05, and 0.05 is calculated to be 0.08. Since this is below the detection limit of 0.1, the reported value is ND < 0.1.

3.4 Summary of Results

The results of the tests performed at Shawnee Unit Number 3 are listed in the following tables. The flow rates measured at the Shawnee Unit Number 3 Baghouse Outlet Duct are not considered representative of the actual flow rates because of the high cyclonic flow and the reverse air flow from the baghouse, therefore flow measurements were collected from both inlet locations. The outlet duct flow rate was calculated based on the unit heat input, F_d factor, and measured oxygen concentration.

Table 3-2 Shawnee Unit Number 3 Source Emissions Results

Inlet Gas Properties (Duct B)	Run Number 1	Run Number 2	Run Number 3
Test Date	10/28/99	10/29/99	10/29/99
Test Time	1955-2025	0737-0807	1209-1239
Flow Rate - ACFM	308,407	304,811	310,165
Flow Rate – DSCFM*	180,988	182,865	183,822
% Water Vapor - % Vol.	7.35	5.52	6.63
CO_2 - %	11.6	11.6	11.0
O_2 - %	8.2	8.2	8.3
% Excess Air @ Sampling Point	63	63	63
Temperature - °F	340	337	338
Pressure – "Hg	28.61	28.57	28.60
Volume Dry Gas Sampled – DSCF*	21.783	21.001	21.552
Inlet Gas Properties (Duct A)	Run Number 1	Run Number 2	Run Number 3
Test Date	10/28/99	10/29/99	10/29/99
Test Time	1615-1839	0855-1119	1435-1659
Flow Rate - ACFM	288,479	291,812	293,783
Flow Rate – DSCFM*	174,393	178,023	179,177
% Water Vapor - % Vol.	6.97	6.74	6.68
CO_2 - %	11.6	11.2	11.0
O_2 - %	8.2	8.2	8.6
% Excess Air @ Sampling Point	63	62	68
Temperature - °F	319	315	314
Pressure – "Hg	28.58	28.62	28.56
Percent Isokinetic	94.2	98.7	97.8
Volume Dry Gas Sampled – DSCF*	60.190	64.354	64.213
Total Inlet Flow Rate	355,381	360,888	362,999
Outlet Gas Properties	Run Number 1	Run Number 2	Run Number 3
Test Date	10/28/99	10/29/99	10/29/99
Test Time	1615-1930	0855-1144	1435-1725
Flow Rate – ACFM	817,291	849,909	907,317
Flow Rate – DSCFM* - measured	495,488	513,144	544,350
Flow Rate – DSCFM** - calculated	372,991	385,157	379,775
% Water Vapor - % Vol.	6.28	7.39	6.75
CO_2 - %	11.0	10.0	10.4
O_2 - %	8.8	9.0	9.0
% Excess Air @ Sampling Point	71	72	73
Temperature - °F	306	301	308
Pressure – "Hg	27.97	28.01	27.90
Percent Isokinetic	94.5	103.3	100.4
Volume Dry Gas Sampled – DSCF*	51.049	57.756	59.586

* 29.92 "Hg, 68 °F (760 mm Hg, 20 °C).
** Based on unit heat input, F_d factor, and measured oxygen content.

METCO ENVIRONMENTAL

Table 3-3
Shawnee Unit Number 3 Mercury Removal Efficiency

Run Number	**1**	**2**	**3**	**Average**
Test Date	10/28/99	10/29/99	10/29/99	
Test Time	1615-1930	0855-1144	1435-1725	
Total mercury				
Inlet - lb/10^{12} Btu	2.27	2.86	2.46	2.53
Outlet - lb/10^{12} Btu	0.62	0.01	<1.93	0.21
Removal efficiency - %	72.7	99.7	>21.5	>57.5
Inlet - lbs/hr Btu	3.01E-3	3.84E-3	3.22E-3	3.36E-3
Outlet - lbs/hr Btu	8.23E-4	1.06E-5	<2.56E-3	<7.05E-4
Removal efficiency - %	72.7	72.4	>20.5	>55.2
Particulate mercury				
Inlet - lb/10^{12} Btu	2.27	2.15	2.46	2.29
Outlet - lb/10^{12} Btu	0.02	0.01	<0.09	<0.03
Removal efficiency - %	99.1	99.5	>96.3	>98.3
Inlet - lbs/hr Btu	3.01E-3	2.89E-3	3.22E-3	3.04E-3
Outlet - lbs/hr Btu	2.03E-5	1.06E-5	<1.23E-4	<3.08E-5
Removal efficiency - %	98.3	99.6	>96.2	>98.0
Oxidized mercury				
Inlet - lb/10^{12} Btu	<0.83	0.71	<0.82	<0.51
Outlet - lb/10^{12} Btu	<0.90	<0.87	<0.86	<0.90
Removal efficiency - %	----	----	----	----
Inlet - lbs/hr Btu	<1.09E-3	9.50E-4	<1.08E-3	<6.78E-4
Outlet - lbs/hr Btu	<1.20E-3	<1.17E-3	<1.14E-3	<1.20E-3
Removal efficiency - %	----	----	----	----
Elemental mercury				
Inlet - lb/10^{12} Btu	<1.04	<0.95	<0.96	<1.04
Outlet - lb/10^{12} Btu	0.61	<1.09	<0.98	<0.55
Removal efficiency - %	----	----	----	----
Inlet - lbs/hr Btu	<1.37E-3	<1.28E-3	<1.26E-3	<1.37E-3
Outlet - lbs/hr Btu	8.02E-4	<1.46E-3	<1.30E-3	<9.71E-4
Removal efficiency - %	----	----	----	----

Table 3-4 Shawnee Unit Number 3 Mercury Speciation Results

Run Number	1	2	3	Average
Test Date	10/28/99	10/29/99	10/29/99	
Test Time	1615-1930	0855-1144	1435-1725	
Inlet Mercury Speciation				
Particulate mercury – µg	3.850	3.900	4.308	—
µg /dscm	2.26	2.14	2.37	2.26
lbs/hr	3.01E-3	2.89E-3	3.22E-3	3.04E-3
lbs/10^{12} Btu	2.27	2.15	2.46	2.29
% of total Hg	100.0	75.2	100.0	—
Oxidized mercury – µg	<1.40	1.280	<1.44	—
µg /dscm	<0.82	0.70	<0.79	<0.50
lbs/hr	<1.09E-3	9.50E-4	<1.08E-3	<6.78E-4
lbs/10^{12} Btu	<0.83	0.71	<0.82	<0.51
% of total Hg	0.0	24.8	0.0	—
Elemental mercury - µg	<1.76	<1.72	<1.68	—
µg /dscm	<1.03	<0.94	<0.92	<1.03
lbs/hr	<1.37E-3	<1.28E-3	<1.26E-3	<1.37E-3
lbs/10^{12} Btu	<1.04	<0.95	<0.96	<1.04
% of total Hg	0.0	0.0	0.0	—
Total mercury – µg	3.850	5.180	4.308	—
µg /dscm	2.26	2.84	2.37	2.49
lbs/hr	3.01E-3	3.84E-3	3.22E-3	3.36E-3
lbs/10^{12} Btu	2.27	2.86	2.46	2.53
Outlet Mercury Speciation				
Particulate mercury – µg	0.021	0.012	<0.146	—
µg /dscm	0.01	0.01	<0.09	<0.02
lbs/hr**	2.03E-5	1.06E-5	<1.23E-4	<3.08E-5
lbs/10^{12} Btu	0.02	0.01	<0.09	<0.03
% of total Hg	3.2	100.0	0.0	—
Oxidized mercury – µg	<1.24	<1.33	<1.35	—
µg /dscm	<0.86	<0.81	<0.80	<0.86
lbs/hr**	<1.20E-3	<1.17E-3	<1.14E-3	<1.20E-3
lbs/10^{12} Btu	<0.90	<0.87	<0.86	<0.90
% of total Hg	0.0	0.0	0.0	—
Elemental mercury - µg	0.830	<1.66	<1.54	—
µg /dscm	0.57	<1.01	<0.91	<0.51
lbs/hr**	8.02E-4	<1.46E-3	<1.30E-3	<9.71E-4
lbs/10^{12} Btu	0.61	<1.09	<0.98	<0.55
% of total Hg	98.4	0.0	0.00	—
Total mercury – µg	0.851	0.012	<3.036	—
µg /dscm	0.59	0.01	<1.80	<0.50
lbs/hr**	8.23E-4	1.06E-5	<2.56E-3	<7.05E-4
lbs/10^{12} Btu	0.62	0.01	<1.93	<0.53
Coal Analysis				
Mercury - ppm dry	0.022	0.039	0.024	0.028
Mercury - lb/10^{12} Btu	2.15	3.60	2.18	2.64
Chlorine - ppm dry	200	200	100	167
Moisture - %	12.2	13.4	12.5	12.7
Sulfur - % dry	0.48	0.50	0.49	0.49
Ash - % dry	8.78	9.69	9.68	9.38
HHV - Btu/lb as fired	11,310	11,010	11,180	11,167
Coal flow - lb/hr as fired	117,135	122,198	118,658	119,330
Unit Heat Input – 10^6 Btu/hr*	1,324.8	1,345.4	1,326.6	1,332.3
Total Mercury Mass Rates				
lb/hr input in coal	2.58E-3	4.77E-3	2.85E-3	3.40E-3
lb/hr at Baghouse inlet	3.01E-3	3.84E-3	3.22E-3	3.36E-3
lb/hr emitted	8.23E-4	1.06E-5	<2.56E-3	<7.05E-4

* Calculated based on total inlet flow rate, F_d factor, and inlet oxygen content.

** Calculated based on calculated flow rate.

Table 3-5
Shawnee Unit Number 3 Process Data

Run Number	**1**	**2**	**3**
Test Date	10/28/99	10/29/99	10/29/99
Test Time	1615-1930	0855-1144	1435-1725
Unit Operation			
Unit Load - MW net	141	141	137
Coal Mills in Service	All	All	All
Coal Flow – lbs/hr*	123,157	126,017	123,078
Coal Flow – lbs/hr**	117,135	122,198	118,658
Main Steam Flow – klb/hr	974.8	970.7	932.0
Boiler CEMS data			
CO_2 - %	10.7	10.5	10.3
NO_x – lb/10^6 Btu	0.419	0.384	0.411
Fabric Filter data			
Baghouse Δ Pressure - "H_2O	7.0	7.1	7.5
Gas inlet temperature - °F	343	338	340
Gas outlet temperature - °F	332	327	287

* Data represents the average of 15-minute data points taken during each of the test runs. The coal scale used to measure coal flow for Mill D was not in operation. Data from the three working scales was averaged and assumed for Mill D.

** Data calculated using the measured inlet gas flow rates (dscfm), HHV Btu/lb, and the Oxygen based F factor of 9,780 dscf/million Btu.

4 SAMPLING AND ANALYTICAL PROCEDURES

4.1 Emission Test Methods

The sampling followed the procedures set forth in the Code of Federal Regulations, Title 40, Chapter I, Part 60, Appendix A, Methods 1, 2, 3B, 4, 5, 17, and 19; in the "Standard Test Method for Elemental, Oxidized, Particle-bound, and Total Mercury in Flue Gas Generated from Coal-Fired Stationary Sources (Ontario Hydro Method), Revised July 7, 1999; and ASTM Methods D2234, D6414-99, D2361-95, D-0516, D-3174, and D-3286.

A preliminary velocity traverse was made according to EPA Method 1, at each of the four ports at the inlet sampling location, in order to determine the uniformity and magnitude of the flow prior to testing. All traverse points were checked for cyclonic flow and the average angle was equal to 0.9 degrees. Alternate procedures would be required if the angle of cyclonic flow were greater than 20 degrees. Six traverse points were sampled from each of the four ports, for a total of twenty-four traverse points.

A preliminary velocity traverse was made according to EPA Method 1, at each of the twenty-seven accessible ports at the outlet sampling locations, in order to determine the uniformity and magnitude of the flow prior to testing. Port G located on the East duct was not traversed due to obstructions located in the test port. All traverse points were checked at each of the other ports for cyclonic flow and the average angle was equal to 22.7 degrees. Three traverse points were sampled from Ports B, D, H, K, and M on the East duct and Ports B, E, F, J, and M on the West duct, for a total of thirty traverse points. The cyclonic flow at the ports sampled was less than 20 degrees.

The sampling trains were leak-checked at the end of the nozzle at 15 inches of mercury vacuum before each test, and again after each test at the highest vacuum reading recorded during each test. This was done to predetermine the possibility of a diluted sample.

The pitot tube lines were checked for leaks before and after each test under both a vacuum and a pressure. The lines were also checked for clearance and the manometer was zeroed before each test.

Integrated orsat samples were collected and analyzed according to EPA Method 3B during each test.

4.1.1 Mercury

Triplicate samples for mercury were collected. The samples were taken according to EPA Methods 1, 2, 3B, 4, 5, and 17; and the Ontario Hydro Method, Revised July 7, 1999. At the inlet sampling location, samples of six-minute duration were taken isokinetically at each of the twenty-four traverse points for a total sampling time of 144 minutes. Data was recorded at three-minute intervals. At the outlet sampling location, samples of five-minute duration were taken isokinetically at each of the thirty traverse points for a total sampling time of 150 minutes. Data was recorded at five-minute intervals. Blank train samples and reagent blanks were submitted.

The "front-half" of the sampling train at the inlet sampling location contained the following components:

Teflon Coated Nozzle
In-stack Quartz Fiber Thimble and Backup Filter and Teflon Coated Support
Heated Glass Probe @ > 248°F

The "front-half" of the sampling train at the outlet sampling location contained the following components:

Teflon Coated Nozzle
In-stack Quartz Fiber Filter and Teflon Coated Support
Heated Glass Probe @ > 248°F

The "back-half" of the sampling train at both sampling locations contained the following components:

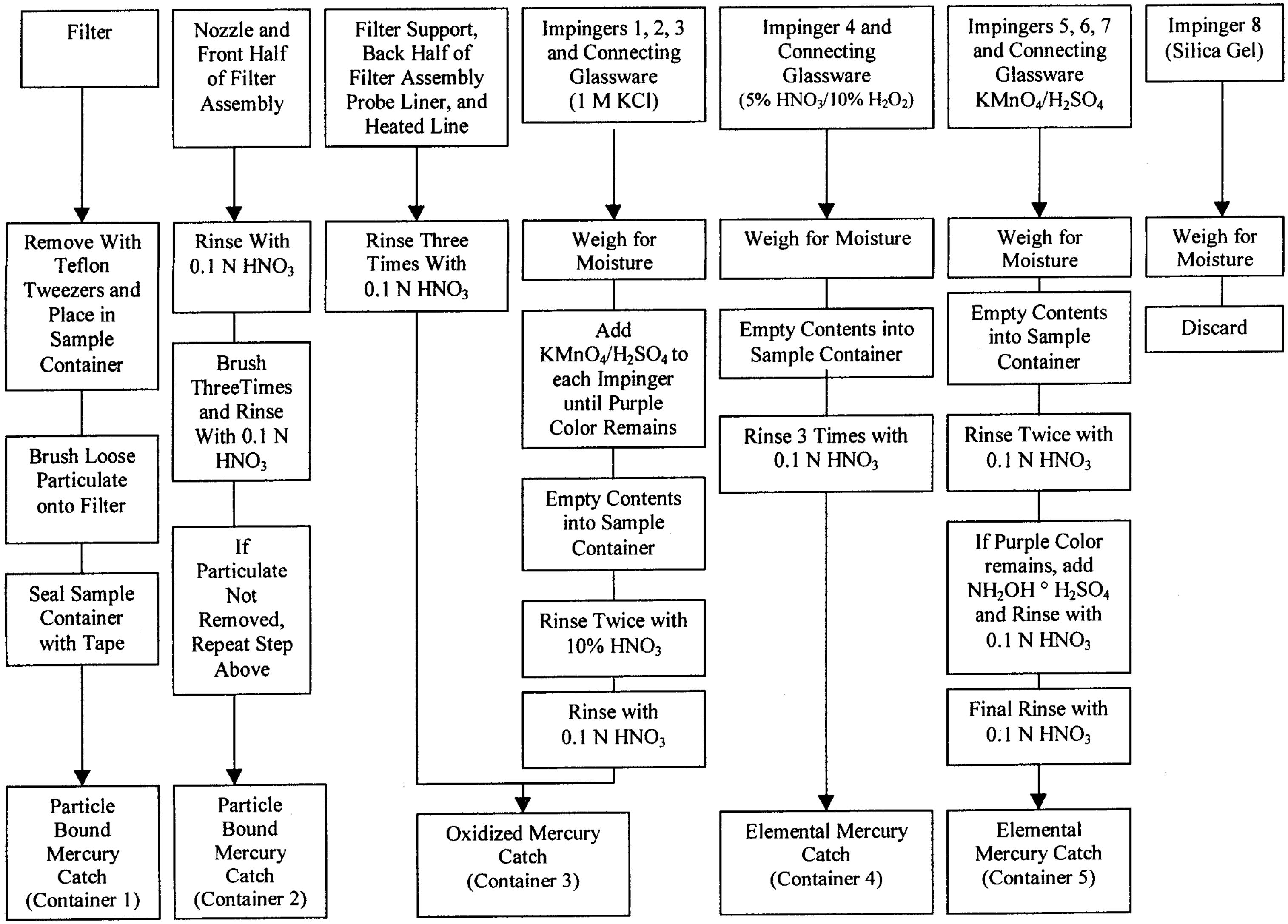
Impinger Number	Impinger Type	Impinger Contents	Amount	Parameter Collected
1	Modified Design	1 mol/L KCL	100 ml	Oxidized Mercury and Moisture
2	Modified Design	1 mol/L KCL	100 ml	Oxidized Mercury and Moisture
3	Greenburg-Smith Design	1 mol/L KCL	100 ml	Oxidized Mercury and Moisture
4	Modified Design	5% HNO_3 and 10% H_2O_2	100 ml	Elemental Mercury and Moisture
5	Modified Design	4% $KMnO_4$ and 10% H_2SO_4	100 ml	Elemental Mercury and Moisture
6	Modified Design	4% $KMnO_4$ and 10% H_2SO_4	100 ml	Elemental Mercury and Moisture
7	Greenburg-Smith Design	4% $KMnO_4$ and 10% H_2SO_4	100 ml	Elemental Mercury and Moisture
8	Modified Design	Silica	200 g	Moisture

All glassware was cleaned prior to use according to the guidelines outlined in EPA Method 29, Section 5.1.1 and the Ontario Hydro Method, Revised July 7, 1999, Section 13.2.15. All glassware connections were sealed with Teflon tape.

At the conclusion of each test, the filter and impinger contents were recovered according to procedures outlined in the Ontario Hydro Method, Revised July 7, 1999, Section 13.2.

Mercury samples were analyzed by Cold Vapor Atomic Absorption and Fluorescence Spectroscopy.

Figure 4-1 Sample Recovery Scheme for the Mercury Speciation Sampling Train Ash Sample (Method 17 Configuration)



4.1.2 Moisture

The samples were taken according to EPA Methods 3B and 4. Samples of thirty-minute duration were taken from a single point. Data was recorded in five-minute intervals.

The “front-half” of the sampling train at the outlet sampling location contained the following components:

In-stack Quartz Fiber Filter and Teflon Coated Support
Heated Glass Probe @ > 248°F

The “back-half” of the sampling train contained the following components:

Impinger Number	Impinger Type	Impinger Contents	Amount	Parameter Collected
1	Modified Design	6% Hydrogen Peroxide	100 ml	Moisture
2	Greenburg-Smith Design	6% Hydrogen Peroxide	100 ml	Moisture
3	Modified Design	6% Hydrogen Peroxide	100 ml	Moisture
4	Modified Design	Silica	200 g	Moisture

4.2 Process Test Methods

ASTM D2234 method of coal sampling was followed. For each test run, a grab sample of coal was collected from each coal scale immediately downstream of the coal bunkers. One composite sample was prepared for analysis from the individual feeder samples. Each sample was analyzed for mercury, chlorine, sulfur, ash, and Btu content by ASTM Methods D6414-99, D2361-95, D-0516, D-3174, and D-3286, respectively.

4.3 Sample Tracking and Custody

Samples and reagents were maintained in limited access, locked storage at all times prior to the test dates. While on site, they were at an attended location or in an area with limited access. Off site, METCO and TestAmerica provided limited access, locked storage areas for maintaining custody.

Chain of custody forms are located in Appendix F. The chain of custody forms provide a detailed record of custody during sampling, with the initials noted of the individuals who loaded and recovered impinger contents and filters, and performed probe rinses.

All samples were packed and shipped in accordance with regulations for hazardous substances.

5 QA/QC ACTIVITIES

The major project quality control checks are listed in Table 5-1. Matrix Spike Summaries are listed in Table 5-2. Duplicate and Triplicate Analyses Summaries are listed in Table 5-3. Additional method-specific QC checks are presented in Table 5-4 (Methods 1 and 2), Table 5-5 (Method 5/17 sampling), and Table 5-6 (Ontario Hydro sample recovery and analysis). These tables also include calibration frequency and specifications.

Table 5-1
Major Project Quality Control Checks

QC Check	*Information Provided*	*Results*
Blanks		
Reagent blank	Bias from contaminated reagent	No Mercury was detected
Field blank	Bias from handling and glassware	No Mercury was detected
Spikes		
Matrix spike	Analytical bias	Results were 75% - 125% recovery
Replicates		
Duplicate analyses	Analytical precision	Results were < 10% RPD
Triplicate analyses	Analytical precision	Results were < 10% RPD

Table 5-2
Unit Number 3 Baghouse Matrix Spike Summary

Sampling Location	*Run Number*	*Container*	*Results (ug)*	*True Value (ug)*	*Recovery (%)*
A Inlet Duct	1	4	3.04	3.32	92
Outlet Duct	1	1A	0.0495	0.050	99
Outlet Duct	2	2	6.83	6.63	103
Outlet Duct	3	3	6.46	6.73	96
Outlet Duct	3	4	3.06	3.06	100
Outlet Duct	3	5	4.94	4.75	104
Reagent Blank	—	12B	0.053	0.050	106

Table 5-3
Unit Number 3 Baghouse Duplicate and Triplicate Analyses Summary

Sampling Location	*Run Number*	*Container*	*Results (ug)*	*Duplicate Results (ug)*	*RPD*	*Triplicate Results (ug)*	*RPD*
A Inlet Duct	1	1A	3.85	3.85	0	----	----
		1B	<0.01	<0.01	0	<0.01	0
		2	<0.182	<0.182	0	----	----
		3	<1.40	<1.40	0	----	----
		4	<0.66	<0.66	0	----	----
		5	<1.10	<1.10	0	----	----
	2	1A	3.90	3.71	4.8	----	----
		1B	<0.01	<0.01	0	----	----
		2	<0.154	<0.154	0	<0.154	0
		3	1.28	1.23	4.0	----	----
		4	<0.70	<0.70	0	----	----
		5	<1.02	<1.02	0	----	----
	3	1A	4.10	3.98	3.0	----	----
		1B	<0.01	<0.01	0	----	----
		2	0.208	0.214	0.3	----	----
		3	<1.44	<1.44	0	<1.44	0
		4	<0.72	<0.72	0	<0.72	0
		5	<0.96	<0.96	0	<0.96	0
A Outlet Duct	1	1A	0.021	0.020	4.4	----	----
		2	<0.110	<0.110	0	----	----
		3	<1.24	<1.24	0	----	----
		4	<0.68	<0.68	0	----	----
		5	0.83	0.83	0	----	----
	2	1A	0.012	0.012	0	----	----
		2	<0.230	<0.230	0	----	----
		3	<1.33	<1.33	0	----	----
		4	<0.70	<0.70	0	----	----
		5	<0.96	<0.96	0	----	----
	3	1A	<0.01	<0.01	0	<0.01	0
		2	<0.136	<0.136	0	----	----
		3	<1.35	<1.35	0	----	----
		4	<0.62	<0.62	0	----	----
		5	<0.92	<0.92	0	----	----

METCO ENVIRONMENTAL

Table 5-4
QC Checklist and Limits for Methods 1 and 2

Quality Control Activity	Acceptance Criteria and Frequency	Reference
Measurement site evaluation	>2 diameters downstream and 0.5 diameters upstream of disturbances*	Method 1, Section 2.1
Pitot tube inspection	Inspect each use for damage, once per program for design tolerances	Method 2, Figures 2-2 and 2-3
Thermocouple	+/- 1.5% (°R) of ASTM thermometer, before and after each test mobilization	Method 2, Section 4.3
Barometer	Calibrate each program vs. mercury barometer or vs. weather station with altitude correction	Method 2, Section 4.4

* Although the outlet sampling location does not meet the requirements of EPA Method 1, three-dimensional flow testing as described in EPA Method 1 was not performed. Port G located on the East duct was not traversed due to obstructions located in the test port. All traverse points were checked at each of the other ports for cyclonic flow and the average angle was equal to 22.7 degrees. Three traverse points were sampled from Ports B, D, H, K, and M on the East duct and Ports B, E, F, J, and M on the West duct, for a total of thirty traverse points. The cyclonic flow at the ports sampled was less than 20 degrees.

Table 5-5 QC Checklist and Limits for Method 5/17 Sampling

Quality Control Activity	Acceptance Criteria and Frequency	Reference
Pre-mobilization checks		
Gas meter/orifice check	Before test series, Y_D +/- 5% (of original Y_D)	Method 5, Section 5.3
Probe heating system	Continuity and resistance check on element	
Nozzles	Note number, size, material	
Glassware	Inspect for cleanliness, compatibility	
Thermocouples	Same as Method 2	
On-site pre-test checks		
Nozzle	Measure inner diameter before first run	Method 5, Section 5.1
Probe heater	Confirm ability to reach temperature	
Pitot tube leak check	No leakage	Method 2, Section 3.1
Visible inspection of train	Confirm cleanliness, proper assembly	
Sample train leak check	$\leq$0.02 cf at 15" Hg vacuum	Method 5, Section 4.1.4
During testing		
Probe and filter temperature	Monitor and confirm proper operation	
Manometer	Check level and zero periodically	
Nozzle	Inspect for damage or contamination after each traverse	Method 5, Section 5.1
Probe/nozzle orientation	Confirm at each point	
Post test checks		
Sample train leak check	$\leq$0.02 cf at highest vacuum achieved during test	Method 5, Section 4.1.4
Pitot tube leak check	No leakage	Method 2, Section 3.1
Isokinetic ratio	Calculate, must be 90-110%	Method 5, Section 6
Dry gas meter calibration check	After test series, Y_D +/- 5%	Method 5, Section 5.3
Thermocouples	Same as Method 2	
Barometer	Compare w/ standard, +/- 0.1" Hg	

Table 5-6 QC Checklist and Limits for Ontario Hydro Mercury Speciation

Quality Control Activity	Acceptance Criteria and Frequency	Reference
Pre-mobilization activities		
Reagent grade	ACS reagent grade	Ontario Hydro Section 8.1
Water purity	ASTM Type II, Specification D 1193	Ontario Hydro Section 8.2
Sample filters	Quartz; analyze blank for Hg before test	Ontario Hydro Section 8.4.3
Glassware cleaning	As described in Method	Ontario Hydro Section 8.10
On-site pre-test activities		
Determine SO_2 concentration	If >2500 ppm, add more HNO_3-H_2O_2 solution	Ontario Hydro Section 13.1.13
Prepare KCl solution	Prepare batch as needed	Ontario Hydro Section 8.5
Prepare HNO_3-H_2O_2 solution	Prepare batch as needed	Ontario Hydro Section 8.5
Prepare H_2SO_4-$KMnO_4$ solution	Prepare daily	Ontario Hydro Section 8.5
Prepare HNO_3 rinse solution	Prepare batch as needed; can be purchased premixed	Ontario Hydro Section 8.6
Prepare hydroxylamine solution	Prepare batch as needed	Ontario Hydro Section 8.6
Sample recovery activities		
Brushes and recovery materials	No metallic material allowed	Ontario Hydro Section 13.2.6
Check for $KMnO_4$ Depletion	If purple color lost in first two impingers, repeat test with more HNO_3-H_2O_2 solution	Ontario Hydro Section 13.1.13
Probe cleaning	Move probe to clean area before cleaning	Ontario Hydro Section 13.2.1
Impinger 1,2,3 recovery.	After rinsing, add permanganate until purple color remains to assure Hg retention	Ontario Hydro Section 13.2.8
Impinger 5,6,7 recovery.	If deposits remain after HNO_3 rinse, rinse with hydroxylamine sulfate. If purple color disappears after hydroxylamine sulfate rinse, add more permangante until color returns	Ontario Hydro Section 13.2.10
Impinger 8	Note color of silica gel; if spent, regenerate or dispose.	Ontario Hydro Section 13.2.11
Blank samples		
0.1 N HNO_3 rinse solution	One reagent blank per batch.	Ontario Hydro Section 13.2.12
KCl solution	One reagent blank per batch.	Ontario Hydro Section 13.2.12
HNO_3-H_2O_2 solution	One reagent blank per batch.	Ontario Hydro Section 13.2.12
H_2SO_4-$KMnO_4$ solution	One reagent blank per batch.	Ontario Hydro Section 13.2.12
Hydroxylamine sulfate solution	One reagent blank per batch.	Ontario Hydro Section 13.2.12
Unused filters	Three from same lot.	Ontario Hydro Section 13.2.12
Field blanks	One per set of tests at each test location.	Ontario Hydro Section 13.4.1
Laboratory activities		
Assess reagent blank levels	Target <10% of sample value or <10x instrument detection limit. Subtract as allowed.	Ontario Hydro Section 13.4.1
Assess field blank levels	Compare to sample results. If greater than reagent blanks or greater than 30% of sample values, investigate. Subtraction of field blanks not allowed.	Ontario Hydro Section 13.4.1
Duplicate/triplicate samples	All CVAAS runs in duplicate; every tenth run in triplicate. All samples must be within 10% of each other; if not, recalibrate and reanalyze.	Ontario Hydro Section 13.4.1

6 DESCRIPTION OF TESTS

Personnel from METCO Environmental arrived at the plant at 4:30 p.m. on Wednesday, October 27, 1999. After meeting with plant personnel and attending a brief safety meeting, the equipment was moved onto the Unit Number 3 Baghouse Inlet Ducts and Outlet Duct. The equipment was secured for the night. All work was completed at 9:30 p.m.

On Thursday, October 28, work began at 7:00 a.m. The equipment was prepared for testing. The preliminary data was collected. Testing was delayed due to power problems at the sampling locations. The first set of tests for mercury on the Unit Number 3 Baghouse A Inlet Duct and Unit Number 3 Baghouse Outlet Duct began at 4:15 p.m. and was completed at 7:30 p.m. The first test for flow rate on the Unit Number 3 Baghouse B Inlet Duct began at 7:55 p.m. and was completed at 8:25 p.m. The samples were recovered. The equipment was secured for the night. All work was completed at 9:45 p.m.

On Friday, October 29, work began at 7:00 a.m. The equipment was prepared for testing. The second test for flow rate on the Number 3 Baghouse B Inlet Duct began at 7:37 a.m. Testing continued until the completion of the third test at 12:39 p.m. The second set of tests for mercury on the Number 3 Baghouse A Inlet Duct and Unit Number 3 Baghouse Outlet Duct began at began at 8:55 a.m. Testing continued until the completion of the third set of tests at 5:25 p.m.

The samples were recovered. The equipment was moved off of the sampling locations and loaded into the sampling van. The samples and the data were transported to METCO Environmental's laboratory in Dallas, Texas, for analysis and evaluation.

Operations at Tennessee Valley Authority, Shawnee Fossil Plant, Unit Number 3 Baghouse Inlet Ducts and Outlet Duct, located in West Paducah, Kentucky, for the Electric Power Research Institute, were completed at 8:00 p.m. on Friday, October 29, 1999.

Billy J. Mullins, Jr.

Billy J. Mullins, Jr. P.E.
President

7 APPENDICES

A. Source Emissions Calculations

B. Field Data

C. Calibration Data

D. Analytical Data

E. Unit Operational Data

F. Chain of Custody Records

G. Resumes